Mobile Detection Assessment and Response Systems (MDARS)
A Force Protection, Physical Security Operational Success

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ABSTRACT

MDARS is a Semi-autonomous unmanned ground vehicle with intrusion detection & assessment, product & barrier assessment payloads. Its functions include surveillance, security, early warning, incident first response and product and barrier status primarily focused on a depot/munitions security mission at structured/semi-structured facilities. MDARS is in Systems Development and Demonstration (SDD) under the Product Manager for Force Protection Systems (PM-FPS). MDARS capabilities include semi-autonomous navigation, obstacle avoidance, motion detection, day and night imagers, radio frequency tag inventory/barrier assessment and audio challenge and response. Four SDD MDARS Patrol Vehicles have been undergoing operational evaluation at Hawthorne Army Depot, NV (HWAD) since October 2004. Hawthorne personnel were trained to administer, operate and maintain the system in accordance with the US Army Military Police School (USAMPS) Concept of Employment and the PM-FPS MDARS Integrated Logistic Support Plan. The system was subjected to intensive periods of evaluation under the guidance and control of the Army Test and Evaluation Center (ATEC) and PM-FPS. Significantly, in terms of User acceptance, the system has been under the "operational control" of the installation performing security and force protection missions in support of daily operations. This evaluation is intended to assess MDARS operational effectiveness in an operational environment. Initial observations show that MDARS provides enhanced force protection, can potentially reduce manpower requirements by conducting routine tasks within its design capabilities and reduces Soldier exposure in the initial response to emerging incidents and situations. Success of the MDARS program has been instrumental in the design and development of two additional robotic force protection programs. The first was the USAF Force Protection Battle Lab sponsored Remote Detection Challenge & Response (REDCAR) concept demonstration executed by the Air Force Robotics Lab (AFRL). The REDCAR used an MDARS PUV as the central robotic technology and expanded the concept to incorporate a smaller high speed platform (SCOUT) equipped with lethal, non-lethal and challenge components as an engagement platform and, in a marsupial configuration on the MDARS, a small UGV that can be deployed to investigate close quarters areas. The Family of Integrated Rapid Response Equipment (FIRRE) program further expands these concepts by incorporating and adapting other mobile/tactical force protection equipment with a more robust Unmanned Ground Vehicle into an "Expeditionary" configuration to provide the current force with a rapidly deployable force protection system that can operate in austere less structured and protected environments. A USAMPS/ MANCEN sponsored "FIRRE System Demonstration" in Iraq is scheduled to begin in FY '07.

Keywords: force protection, physical security, unmanned ground vehicles, Mobile Detection Assessment Response System (MDARS), robotics, Research, Development, Testing and Engineering (RDT&E), unmanned ground systems, Combat Service Support and Combat Support, Soldiers, modular, current force robotic initiatives, Family of Integrated Rapid Response Equipment (FIRRE), Remote Detection Challenge and Response (REDCAR).

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THE BACKGROUND:

The Mobile Detection Assessment Response System (MDARS) provides Continental US (CONUS) installation commanders an electro-mechanical capability to conduct semi-autonomous random patrols and surveillance activities to include barrier assessment and theft detection functions. The MDARS can be used in a variety of military installations (i.e., depots, storage areas for rail, air, and port facilities, and Arms, Ammunition and Explosives (AA&E) storage facilities) to detect unauthorized access to a facility; verify the status of barriers and products; and investigate the source of alarms from remote locations before dispatching armed guards to the scene. Current Intrusion Detection System (IDS) technology requires manual assessment and response to alarms that could expose personnel to life threatening situations. MDARS provides commanders with an enhanced capability to counter covert and overt threats, reduce risk to personnel, and reduce manpower requirements used for security and inventory functions.

An Operational and Organizational Plan for a robotic security system was approved in March 1985. The concept formulation package was completed in May 1991 and showed MDARS to be the best approach for satisfying the mission need for both an interior and exterior systems. In 1992, the Secretary of the Army for Research, Development and Acquisition issued a memorandum directing the MDARS program development using Office of the Under Secretary of Defense funds with the U.S. Army Materiel Command as principal proponent which approved a Requirements Document in June 1993. In February 1994, the Defense Logistics Agency also issued a Mission Need Statement for MDARS capability. The U.S. Army Training and Doctrine Command (TRADOC) approved the MDARS Operational Requirements Document (ORD) in May 1996. A Broad Agency Announcement contract was awarded Robotic Systems Technology of Westminster, MD in September 1993. This effort culminated in the Technical Feasibility Test (TFT) of a prototype MDARS-Exterior (MDARS-E) conducted in May 2000 at Aberdeen Proving Grounds, MD. (See Figure 1) With the TFT results, an updated MDARS ORD was prepared and submitted in support of a Milestone I/II for the MDARS-E. (Approved in December 2004)

Figure 1: The MDARS-E Prototype Vehicle during TFT May 2000 at APG, MD

The successful Milestone decision approved moving the MDARS program into the System Design and Development (SDD) phase of the acquisition program. And, following that event, a four year SDD contract was awarded in 2002 to General Dynamics Robotic Systems (GDRS), formerly RST. The MDARS program uses an evolutionary acquisition strategy and spiral development approach for development. Technology readiness and funding for robotics necessitates this methodology. The Capabilities Production Document (CPD) is a conversion from an ORD to a CPD in support of a Milestone C, scheduled for December 2006, in accordance with the DoD 5000 series and Chairman Of Joint Chiefs of Staff Manual and Instructions, and provides the attributes (Threshold and

Objective) for the MDARS Increment-1. The CPD was formulated after the MDARS final SDD critical design readiness review. Tradeoff decisions have been made and a more precise determination of the performance parameters is incorporated. Initial fielding of the system begins in Fiscal Year (FY) 08 and continues until all systems required by the Office of the Provost Marshal General have been delivered.

FY2004 was a significant test year for the MDARS. Effort was initiated in testing both software and hardware. SPAWAR completed several iterations of software regression testing and GDRS completed Product Qualification Testing 1a at their facility. All test activity was conducted under the watchful eye of Army Test Center personnel. In addition, and following the selection of Hawthorne Army Depot, NV as the system operational assessment facility, GDRS was directed to conduct a survey of the facility in preparation for the installation of the MDARS and identify facility preparation required to support the system. This was accomplished, infrastructure was upgraded as needed and the system installation was initiated in the 4th Quarter of 2004.

In FY 2005, three major and significant activities were accomplished in the MDARS program. The first was a modeling and simulation effort placing the MDARS in a tactical environment was conducted with favorable results. This effort expanded on the MDARS capability to be a semi-autonomous, unmanned patrol vehicle in a structured / semi-structured environment, to operations outside a defined perimeter on semi to unstructured terrain in support of force protection/physical security missions in a more hostile environment. As a result, a concept has been initiated, known as the Family of Integrated Rapid Response Equipment (FIRRE), to integrate force protection sensors with robotic response equipment into a self supporting rapid response mission set and is currently undergoing the Joint Capabilities Integration and Development System analysis. It is anticipated that a series of FIRRE technology demonstrations, both CONUS and OCONUS, will be conducted in FY 06-07.

The second major event was the conduct of a 30 day Early User Appraisal (EUA) of the MDARS in the 3rd Quarter of FY 2005 at Hawthorne Army Depot, NV, an operational arms, ammunition and explosives storage area. Hawthorne personnel were trained to perform all System Administration, Operator, organizational maintenance and preventive maintenance checks & services tasks and functions. The EUA was an intense 30 days of a variety of exercises and scenario situations intended to identify system strengths and weaknesses.

The third event was the completion of a year long system assessment in that same environment. This is the focus of this paper.

THE OPERATIONAL CONCEPT:

The MDARS system consists of robotic platforms capable of preprogrammed autonomous movement, motion detection, barrier, product, incident assessment subsystems, two way communications capability, and in the future when supported by policy, may employ a non-lethal response to be added in the modernization phase following Milestone C. It will be capable of operating in a stand-alone mode or in conjunction with existing Intrusion Detection Systems (IDS). The full operating system will consist of pair(s) of mobile platforms employing a suite of sensors that are preprogrammed or remotely controlled by an operator located at a remote monitoring and control point. The MDARS will provide commanders a means of conducting semi or fully autonomous random patrols in operational security environments. The MDARS monitor point may be co-located with and operated by existing IDS or Integrated Commercial Intrusion Detection System (ICIDS) monitor point personnel. The MDARS monitor point will have continuous operational control of the system, and can make automatic digitized records of all operations including the capability to record and store video images. MDARS will rely on a radio communication network to ensure continuous two-way communication to include repeaters/relays, possibly fiber optic cabling, laser, or microwave communication technologies. MDARS shall be programmable for a variety of functions or mission profiles. During installation, MDARS will be configured or customized for each designated facility/area and the security mission profiles required of that facility. At a minimum this programming will include: the terrain to be patrolled, its boundaries, designated "way points," operational checks to

be performed, and any specialized response or assessment features programmed into the system during the installation process. MDARS shall be capable of conducting 24 hours a day, 7 days a week operations in most environmental conditions.

MDARS shall be programmable for a variety of functions. During installation, MDARS will be configured or customized for each designated facility/area and mission(s). At a minimum, the terrain to be patrolled and its boundaries, designated “way points”, operational/security checks to be performed, and any specialized features or payload packages will be programmed into the system. MDARS shall be capable of conducting continuous operations. The MDARS will operate within a defined area of operation or an enclosed security area, preferably with limited traffic in the security area during MDARS operations. The routine exception will be other security vehicles. MDARS will operate primarily on the road network within the area, with some off-road capability for short-term operations. The MDARS will be programmed and equipped for its operational area and missions. The MDARS will be smaller than a compact automobile, able to operate within a single lane, and, in order to operate in most environmental conditions, will have robust mobility system and sub-systems designed for exterior use. A high level Operational Concept graphic is shown as Figure 2.

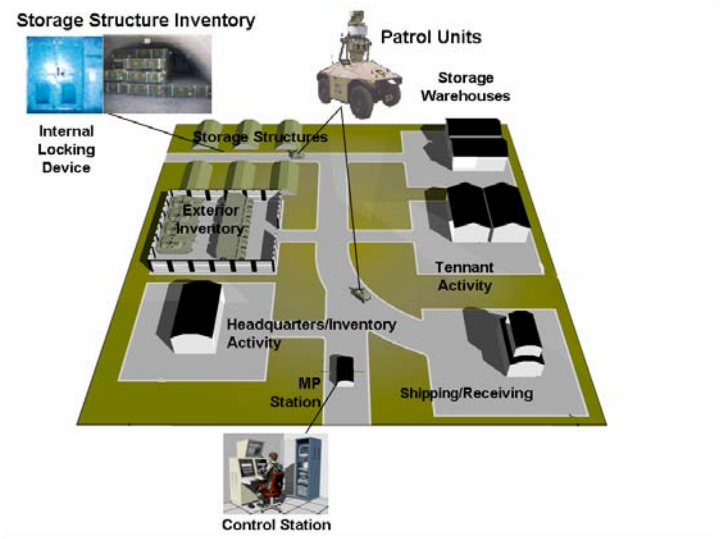

Figure 2. High Level Operational Concept

THE SYSTEM:

MDARS consists of an MDARS Control Station (MCS) and pairs of remote vehicles (patrol units) each equipped with a Mission Payload Suite (MPS). The following descriptions of the systems key features are based on the System Development and Deployment (SDD) system engineering models (pre-production prototypes). Production units are expected to be similar.

(1) The MCS is a distributed processing system that coordinates the operation of multiple semi-autonomous patrol units. The MCS uses the Government-developed (Navy SPAWAR Systems Center, San Diego, CA) Multiple Resource Host Architecture (MRHA) as its application software. The system is designed to run automatically with only minimal human intervention. The MCS provides the user with overall situation awareness and the ability to execute preplanned patrols, random patrols, or user-directed patrols. The MRHA application software (GFE) is a distributed, LAN-based, multi-processing system that can be expanded to accommodate up to 32 platforms. The heart of the system, referred to as the "Supervisor," is a Windows NT based computer with a high-resolution display. The Supervisor represents the highest level in the control hierarchy, both from a distributed computational resource as well as a user interface perspective. A window on the Operator Station displays the remote video image being transmitted from the vehicle. The Supervisor will maintain a ready representation of the "big picture" and will schedule and coordinate the actions of the various Patrol Unit Vehicles (PUV) and display appropriate status and location information to the guard. The Supervisor has at its disposal a number of Planner computers linked over a common high-speed LAN.

The Planner performs virtual path and unrestricted path planning functions on an as needed basis. The Supervisor has access to one or more Operator Stations also linked over the LAN. These Operator Stations consist of individual console input/output stations with Video Graphics Adapter (VGA)-display capability that can be assigned to a particular platform when close attention by a guard is required. This allows the Supervisor to allocate both computational resources and human resources to address the various situations that may arise in the control of remote vehicles.

The graphic at figure 3 shows the major elements/ subsystems that make up the MDARS system and how they fit together.

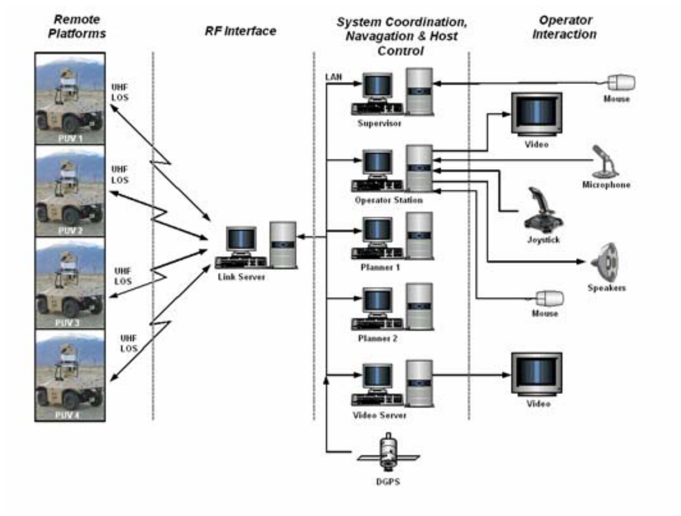

Figure 3. MDARS System Interface Description

The MDARS, by design for this increment, operates as a stand-alone security system with single pair to multiple pairs of robotic platforms. The primary system that MDARS will support is the installation IDS (or the Army fielded ICIDS) by operating in the same area without interference or degradation of either IDS or MDARS. The installation IDS is a fixed point security system with intrusion detection, reporting and, maybe, some fixed camera assessment systems whereas MDARS is an area security system with mobility, assessment, reporting and response. Supplemental payload packages on the MDARS may include additional functional capabilities which will also operate without interference or degradation of basic MDARS function or the installation IDS.

MDARS Increment-1 will be used as non-tactical fixed-site physical security equipment of a low density, contractor supported equipment for limited deployment to Table of Distribution and Allowances (TDA) unit installations. These installations will have IDS or ICIDS as their primary electronic physical security system. MDARS, by design, will be able to carry supplemental payload packages. There are two such packages being developed to operate from the MDARS robotic platform. The Barrier Assessment System (BAS) and a Product Assessment System (PAS) are being co-developed from operational application with MDARS. The BAS can electronically check an electronic lock system via a radio frequency inquiry and response. The PAS uses Radio Frequency Identification (RFID) tags on products with the ability of the MDARS to make an inquiry and report its status. Both systems co-exist on the MDARS as supplemental payload packages, using power and communications assets of MDARS to function in a timely manner. A system depiction incorporating these additional components and capabilities is provided as Figure 4.

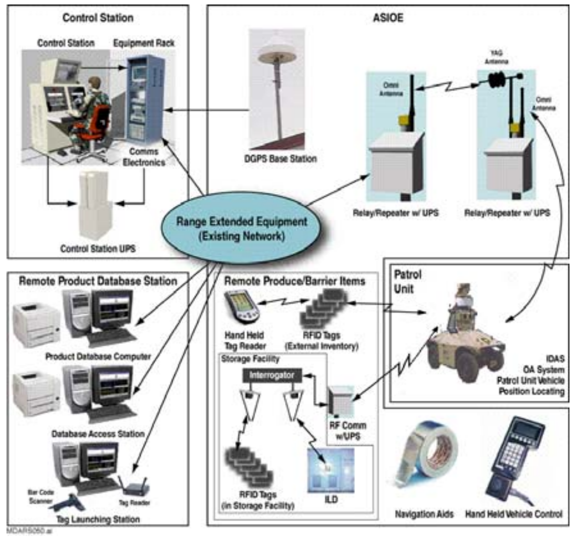

Figure 4. MDARS Increment 1 System Components

(2) The patrol unit has onboard navigation subsystem, communications subsystem, obstacle avoidance subsystem, and a MPS consisting of intrusion detection and assessment system with supplemental payload packages of barrier assessment (BAS) and product assessment (PAS) systems. The actual number of patrol units included in a given system will be site specific. The PAS consists of an interrogator mounted on the PUV, a database linked to the MCS, and a number of Radio Frequency (RF) activated tags. The tags are affixed to items of equipment or products within the patrol area. The PAS interrogator will query the tags and read any stored data. Product database reports include information on expected and calculated tag location, missing tags, misplaced tags, and unexpected tags found. The BAS consists of an interrogator mounted on the PUV, a database linked into the MCS, and a lock mechanism equipped with a sensor and RF transceiver. The locks are installed on storage igloos and buildings. As the PUV conducts patrols, the BAS interrogator reads the lock status. Status is defined as “open,” “closed,” or “error.” The BAS provides an immediate indication that a bunker or building lock has been tampered with or compromised. See Figure 5.

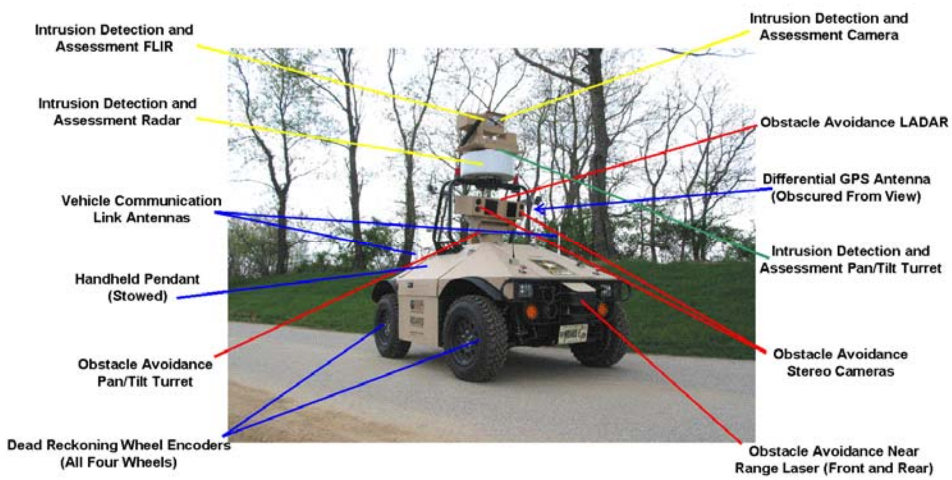

Figure 5. PUV Components.

(3) The Associated Support Items of Equipment consists of Communications Relays/Repeaters, Navigational Aids, Remote Area resources, and differential Global Positioning System. These devices extend the distances between the PUV and the MCS, provide for navigation through the patrol area by the patrol unit, and are the components for indicating functionality at the BAS locations.

THE OPERATIONAL ASSESSMENT:

In October 2005, the MDARS completed a successful, year long Operations Assessment and Early User Appraisal (EUA) period at Hawthorne Army Depot (HWAD) in Nevada, the largest Army munitions storage depot in the world. MDARS, a joint Army-Navy development effort to provide automated robotic intrusion detection, response and inventory/barrier assessment capability for use on DoD facilities, is managed by the US Army Office of the Product Manager, Force Protection Systems (PM-FPS). The *Multiple Resource Host Architecture* (*MRHA*) command-and-control software was developed by SSC San Diego, while the unmanned patrol unit vehicle (PUV) was developed by General Dynamics Robotic Systems (GDRS). The MDARS system deployed to Hawthorne in early FY2005, consisted of four PUVs, the command-and-control console/software, and communications equipment. In addition, other associated items of equipment including the newest Navy high security Internal Locking Device(ILD), store forward communications and RFID tags and readers were installed on selected storage structures. (See Figures 6 through 10)

Figure 6. The 4 PUVs at Hawthorne

Figure 7. 1 of 3 Relay/ Repeater Enclosures

Figure 8. The PAS Store Forward Computer & RFID Tag Reader

Figure 9. The NFESC ILD Installed on a Bunker Door

Figure 10. The MDARS MCS

Selected site personnel between 40 and 64 hours of training and were certified to perform a number of MDARS functions. These functions included system operations, system administration, system maintenance and pre and post patrol Preventive Maintenance Checks and Services (PMCS) on the PUV's. (See Figures 12 through 15) During the year-long effort, which concluded in October 2005, the autonomous PUVs patrolled assigned portions of the depot (about 30 square miles, See Figure 11) for 12 hours per day on weekdays (Monday – Thursday) and 24 hours per day on weekends (Friday – Sunday). Their normal routine mission taskings included intruder detection sentry stops at designated programmed nodes around the patrol area perimeter and at selected points along the patrol paths, monitoring and reporting the status of the high-security ILD's on munitions bunkers, and tracking the presence/location of tagged munitions using active RFID technology.

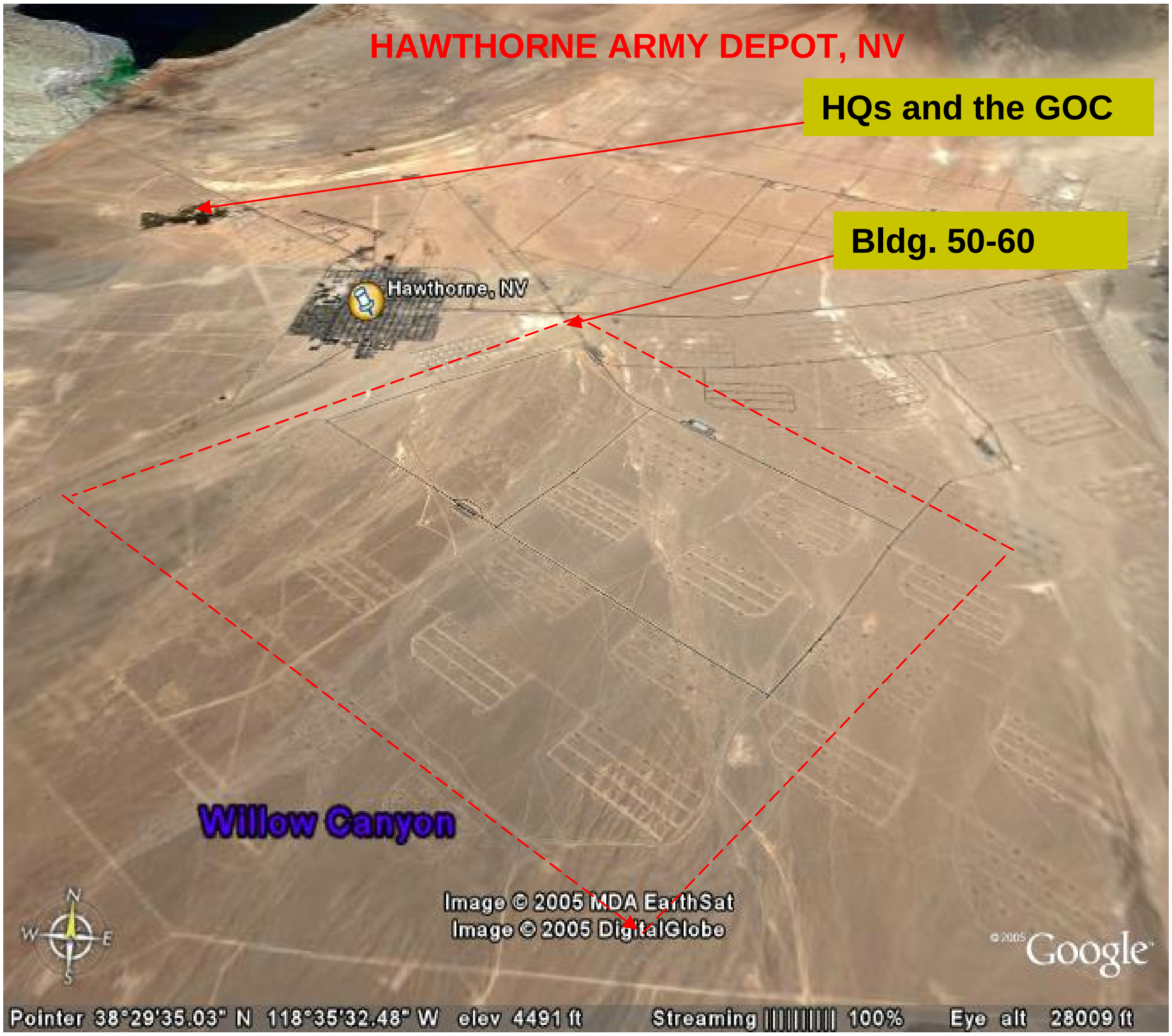

Figure 11. The MDARDS Operating Area Includes 104 Miles of Patrol Path and 260 AA&E Storage Structures

The MDARS command and control console, located in the Guard Operations Center (GOC) was operated by Hawthorne personnel who operated the system as an additional task along with their normal functions of guard operations communications and IDS monitors. During this period, and particularly during the EUA, representatives of the program office introduced selected events (such as intruders, blocked paths, opened locks, and moved containers) to observe not only how both the system and users would respond, but also to observe whether or not the system control was user friendly. In all, over 100 exercise scenarios were introduced over the period. A further objective to identify other contributions that the MDARS could make in emergency situations such as fires, hazardous materials accidents, communications outages, fixed IDS failures, etc. was also addressed. Most efforts in this regard were successful, but depended greatly on the level of comfort and expertise developed by the Operator. Over the course of the system assessment, the four robots patrolled in excess of 2000 hours and traveled over 16,000 kilometers (10,000 miles). Most system operators became very comfortable and competent with normal operation, and acquired varying levels of proficiency in responding to exceptional events such as intruders and open locks and manual control of the PUVs. As an example, driving the PUV between a storage structure headwall and the protective blast barrier, a width of 14 feet, was difficult because of the PUV obstacle avoidance parameters, but it was a driving task that could be accomplished by an operator comfortable with the knowledge that the PUV would not collide with the obstacles it sensed and who could stay with the effort in spite of the close quarters. Automated product tracking using RFID tags was found to be highly reliable, giving near-real-time notification of inventory discrepancies. Most importantly, both robot and MRHA developers gained valuable real-world data on hardware and software performance, as well as potential areas for improvement and the "Users" of the system were able provide valuable input on both hardware and software interface in a real world operational environment.

Figure12. MDARS Trained Mechanic Working On The Brakes

Figure 13. Trained MDARS Operator at the MCS Guard Operation Center (GOC).

Figure14. Guards Performing PMCS

Figure 15. Guards Fueling the PUV

In fact, once comfortable with the effectiveness of MDARS, depot security personnel utilized this asset for several actual security mission needs. These missions included providing temporary short term surveillance on incoming/outgoing staged munitions shipments that were not in IDS protected structures, on temporary surveillance on storage structures experiencing IDS failures and during increased threat level alerts, the PUVs provided an additional measure of over-watch of ammunition storage structures of high interest. These security missions over about a 120 day period provided the installation the potential to avoid over 600 labor hours of compensatory measures required to be implemented under these conditions. This is good news. The installation became somewhat reliant on the system to perform these functions when needed.

This is not to say that there weren't system issues noted by the user in the context of operator and maintenance interfaces. Operators and System Administrators noted a number of changes that would improve the efficiency of operation. The maintainers noted a number of PUV design improvements that could reduce PUV down time and increase system reliability and availability. Training on how to use the system to the best advantage of the guard force was cited as needing improvement. Most of the identified improvements available for resolution in the context of the existing contract were implemented during a rework period that followed the assessment from October 2005 through January 2006, and were a function of being prepared for the start of the Army Test Center conducted Reliability, Availability and Maintainability (RAM) and Production Qualification Testing (PQT-2) that began on 27 February 2006.

In spite of, and perhaps because of, the software, hardware and personnel interface issues that surfaced during the assessment, the MDARS has, in our view, proven to be a success. Much of the performance and support data obtained during the assessment period could not have been developed under any other conditions. We remain impressed with the value of the user observations in terms of the utility of the system. Obviously, we will await the outcome and scoring of the ongoing ATC test and evaluations and Phase 5 of the System Logistic Demonstration. All testing is scheduled to be completed in August of 2006, and then on to the Milestone C Production decision in December 2006. We anticipate being the first semi-autonomous robotic security system to successfully complete the Army acquisition process.

THE WAY AHEAD:

FY 2007 will see the beginning of an MDARS Increment 2 modernization program that will be used to effect engineering changes to incorporate technology advancements, improved commercial products, develop additional specialized supplemental payload packages, meet CPD objectives and system attributes that were deferred from the Increment 1 capability as well as those requirements identified for Increment 2. We will strive to increase in the probability of detection and make improvements in reliability, maintainability and system availability. However, for the user the greatest payoff in capability will come with enhancements in vehicle patrol and response speed and an improved Intrusion and Detection module that provide extended range for detection and assessment. But most importantly to the user is the added capability to conduct detection on the move. This will provide for an incredible increase in the viability utility of robotic systems in force protection and physical security missions.

In part because of the success thus far achieved in the MDARS program and the technology advancements therein, the concept of using semi-autonomous unmanned vehicles in force protection missions has become a more acceptable and viable alternative to people and fixed sensors. Two projects in the early stages of development which have expanded on the MDARS concept are the Air Force Remote Detection Challenge and Response, or REDCAR, system and a follow-on U.S. Army effort to develop a Family of Integrated Rapid Response Equipment system.

The REDCAR project is an Air Force Battle Lab concept evaluation program initiative in response to the Air Force Integrated Base Defense requirement, to provide a robotic component to overall base security and defense. Their concept incorporates three different robotic platforms for different applications. The first is an MDARS like platform (actually one of the six pre-production prototypes made) as a base interior, mobile long range detection and assessment. The second is a smaller more agile platform that carries non-lethal and lethal components and would be used to challenge and respond. The third robotic platform is of the small variety and would be used to search area not accessible by either of the first two platforms.

FIRRE expands upon and moves the REDCAR in to the tactical unstructured environment. It is intended to produce a scalable kit tailored to the mission and intended to be self supporting once deployed. It uses a "system of systems" approach with interface to the next higher level Common Operating Picture. A graphic of the FIRRE as it now looks is shown as Figure 16.

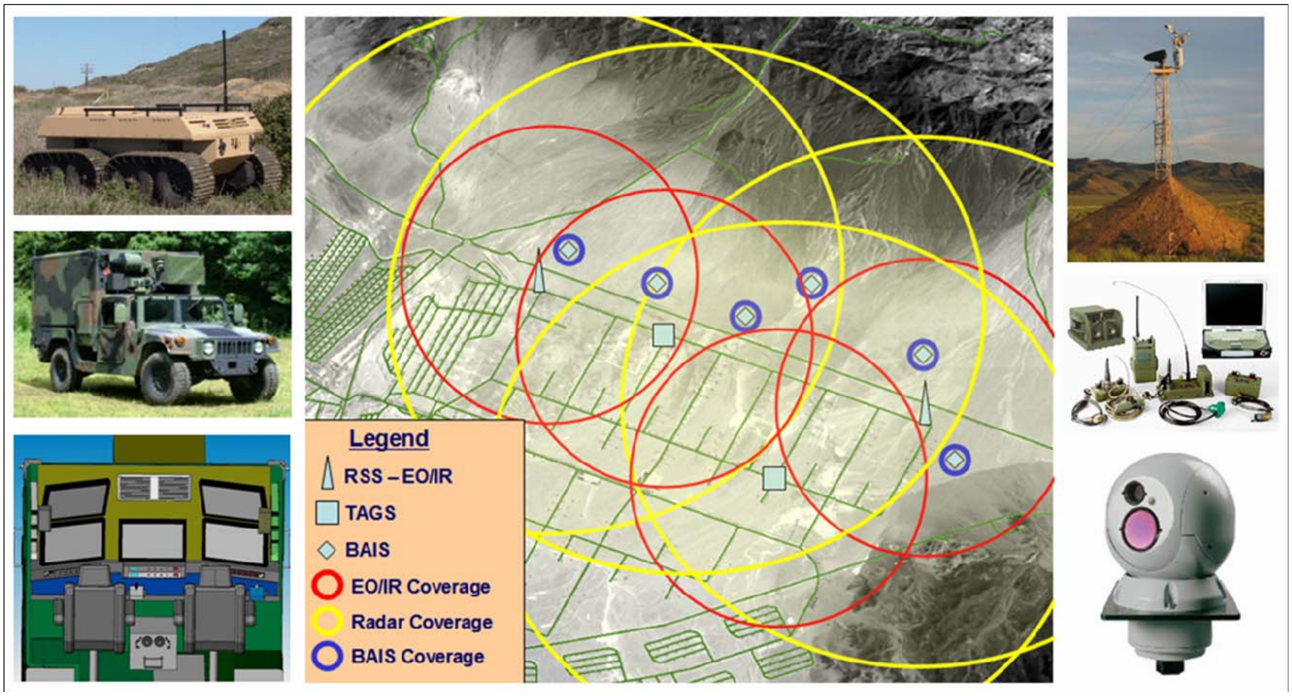

Figure 16. FIRRE

CONCLUSIONS

Autonomous unmanned systems applied to the physical security force protection mission area are a viable enhancement to this mission area. They will be used to greatly reduce risks in high threat incident response and to offset costs associated with manpower used in accomplishing routine repetitive tasks.

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